

# HOW SALT AND SODICITY TOLERANT BARLEY AND OATS ARE?

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Barley and oats are one of the most salt and sodicity tolerant annual crops producers can profitably grow in North Dakota. However, at certain salinity and sodicity levels, even barley and oats can result in significant losses. Especially, important are the levels of salinity and sodicity in the top six inches of the soils. It is the first two inches of soil where seed is planted and at lower salt and sodicity levels, there will be good germination resulting in improved stands and yields. It is important to sample areas where sensitive crops such as soybeans or corn do not grow well and get them analyzed by a soil testing lab for Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR) and pH by using "Saturated Paste Extract Method". For detailed information on sampling and testing soils for salts and sodicity, please refer to the NDSU Publication: SF-1809; "Soil Testing Unproductive Areas".

Sensing the need to determine the threshold of soil salinity (EC) and sodicity (SAR) for barley and oats, four barley and four oat varieties were planted at the Langdon REC site in 2020 at three different levels of salinity and sodicity.

## Soil Analysis Results

Two-foot deep composite soil samples separated into 0-6 and 6-24 inch depths were collected in May, 2020 from each level of salinity and sodicity (replications 1, 2 and 3) by taking three cores for each sample. Soil EC, SAR and pH were analyzed by using saturated paste extract method, whereas, standard methods were used to analyze NO<sub>3</sub>-N, P and K (Table 1).

Table 1. Soil EC, SAR, pH, NO<sub>3</sub>-N, P and K results of the three replications for the 0-6 and 6-24 inch depths.

Site	Sample ID	Depth (inches)	EC (dS/m)	SAR	pH	NO <sub>3</sub> -N (lbs./acre)	P (ppm)	K (ppm)
Rep 1	Low to moderate salinity-sodicity	0-6	3.99	7.12	7.18	5.00	20.00	299.00
		6-24	7.32	15.05	7.71	6.00	5.00	137.00
Rep 2	Moderate to high salinity-sodicity	0-6	7.80	18.13	7.61	6.00	29.00	247.00
		6-24	10.39	20.92	7.95	6.00	2.00	148.00
Rep 3	Very high salinity-sodicity	0-6	10.50	27.30	7.59	5.00	51.00	270.00
		6-24	9.86	32.87	7.81	6.00	4.00	169.00

Replication 1 had low to moderate levels of salinity and sodicity in the 0-6 inch depth (EC = 3.99 dS/m and SAR = 7.12). These levels would be considered low to moderate for tolerant crops like barley and oats, whereas, same levels will be considered high for sensitive crops like soybean. In the 6-24 inch depth of replication 1, both salinity and sodicity increased significantly (EC = 7.32 dS/m and SAR = 15.05) even for crops like barley and oats. Replication 2 had high to very high salinity and sodicity levels in both depths. Replication 3 had higher salinity levels in the 0-6 inch depth compared to replication 2, whereas, salinity levels in the 6-24 inch depths were similar in replication 2 and 3. However, sodicity levels of replication 3 were higher in both depths compared to replication 2 (Table 1).

## Trial Design, Plot sizes and Planting Data

Trial design was randomized split block. Plot sizes were 4.7 X 22 feet. Details are in Table 2.

Table 2. Barley and oat varieties, seeding rates and depths and fertilizer rates per acre.

Crop	Variety	Planting Date	Seeding Rates (live seeds/acre)	Seeding Depth (inches)	Fertilizer Application (lbs./acre)
Barley	AAC Synergy (2-row)	June 1, 2020	1.25 million live seeds per acre	1 to 1 & 1/2	Based on soil NO <sub>3</sub> -N, P and K analysis a uniform rate of 120 lbs. of N was applied through Urea to all three replications with no P and K application.
	ND Genesis (2-row)				
	Pinnacle (2-row)				
	Tradition (6-row)				
Oats	CS Camden		1.00 million live seeds per acre		
	ND Heart				
	Rockford				
	Souris				

## Results and Discussion

### Visual Differences

There were significant differences between the three replications starting from seedbed preparation, germination, plant growth and vigor, maturity, yield and quality.

Seedbed was very mellow in replication 1 (low to moderate salinity-sodicity), whereas, it started getting hard and cloddy with the increase in sodicity in replication 2 (moderate to high salinity-sodicity) and 3 (very high salinity-sodicity). See Pictures 1, 2 and 3 for comparisons.



Picture 1. Replication 1 (low to moderate salinity-sodicity) with nice seedbed on June 1, 2020.



Picture 2. Replication 2 (moderate to high salinity-sodicity) with slightly harder and cloddy seedbed on June 1, 2020.



Picture 3. Replication 3 (very high salinity-sodicity) with hard and cloddy seedbed on June 1, 2020.

Seed germination started in replication 1 (low to moderate salinity-sodicity) around seven days after planting (June 8<sup>th</sup>) and completed in about eleven days (June 11<sup>th</sup>). In replication 2 (moderate to high salinity-sodicity), germination started around June 16<sup>th</sup> and completed around June 23<sup>rd</sup>. So, replication 2 germination was eight to twelve days delayed compared to replication 1. In replication 3 (very high salinity and sodicity) all four barley varieties had zero germination, whereas, some oat seeds started germinating around June 29<sup>th</sup>. See Pictures 4 to 9 for comparisons.



Picture 4 and 5. Germination started in replication 1 (low to moderate salinity-sodicity) around June 8 (left) and completed around June 11, 2020 (right).



Picture 6 and 7. Germination started in replication 2 (moderate to high salinity-sodicity) around June 16 (left) and completed around June 23, 2020 (right).



Picture 8 and 9. Some oat seeds started germinating in replication 3 (very high salinity-sodicity) around June 29, 2020.

On July 17<sup>th</sup>, average barley plant heights in replication 1 (low to moderate salinity-sodicity) were 21.11 to 27.70 inches with 5 to 100 percent heading completed. Oat plant heights were 22.21 to 25.58 inches with 80 to 90 percent heading completed. In replication 2 (moderate to high salinity-sodicity), barley plant heights ranged between 10.03 to 15.56 inches with no heading initiation. Oat plant heights in replication 2 were 9.12 to 15.27 inches with 5 percent heading completed only in the ND Heart plot. No data was taken from replication 3 (high to very high salinity-sodicity) due to no-barley and very negligible growth of oats. See pictures 10 to 15 for comparisons.



Picture 10 and 11. AAC Synergy Barley (left) and ND Heart Oats (right) growth in replication 1 (low to moderate salinity-sodicity) on July 17, 2020.



Picture 12 and 13. AAC Synergy Barley (left) and ND Heart Oats (right) growth in replication 2 (moderate to high salinity-sodicity) on July 17, 2020.



Picture 14 and 15. AAC Synergy Barley (left) and ND Heart Oats (right) growth in replication 3 (high to very high salinity-sodicity) on July 17, 2020.

It was also observed that barley and oat plants adopted to different salinity and sodicity levels by keeping bulk of the roots in the top 6 inches instead of growing into the deeper depths with higher salinity and sodicity levels. That was especially true for replication 1 that had low to moderate levels in the 0-6 inch depth and moderately higher levels in the 6-24 inch depth. However, once surface salinity and sodicity reached high to very high levels in replication 2 and 3 ( $EC = 7.80$  to  $10.50$  dS/m and  $SAR = 18.13$  to  $27.30$ ), germination and growth was poor to negligible. See picture 16 to 19 to compare the rooting depths of barley and oat plants growing in replication 1 and 2. There were no plants in replication 3 to observe rooting depth at that time.



Picture 16 and 17. Barley (left) and oats (right) rooting depths in replication 1 (low to moderate salinity-sodicity) on August 10, 2020.



Picture 18 and 19. Barley (left) and oats (right) rooting depths in replication 2 (moderate to high salinity-sodicity) on August 10, 2020.

Replication 1 (low to moderate salinity-sodicity) barley and oat plots also matured about ten to fourteen days earlier than the plots in replication 2 (moderate to high salinity-sodicity) and were harvested on September 15<sup>th</sup>. Replication 2 was harvested on September 22<sup>nd</sup> while it was still slightly green. Though there was not much to harvest in replication 3 (very high salinity-sodicity) except some oats, which were still not fully mature, plots were combined on September 22<sup>nd</sup>, while harvesting replication 2. See pictures 20 to 25 for comparisons.



Pictures 20 and 21. Replication 1 (low to moderate salinity-sodicity) barley (left) and oat (right) plots ready to be harvested on September 15, 2020.



Pictures 22 and 23. Replication 2 (moderate to high salinity-sodicity) barley (left) and oat (right) plots not quite ready to be harvested on September 15, 2020.



Pictures 24 and 25. Replication 3 (very high salinity-sodicity) barley (left) plots with no-growth and oat (right) plots with sporadic growth not quite ready to be harvested on September 15, 2020.



## Yield and Quality Data

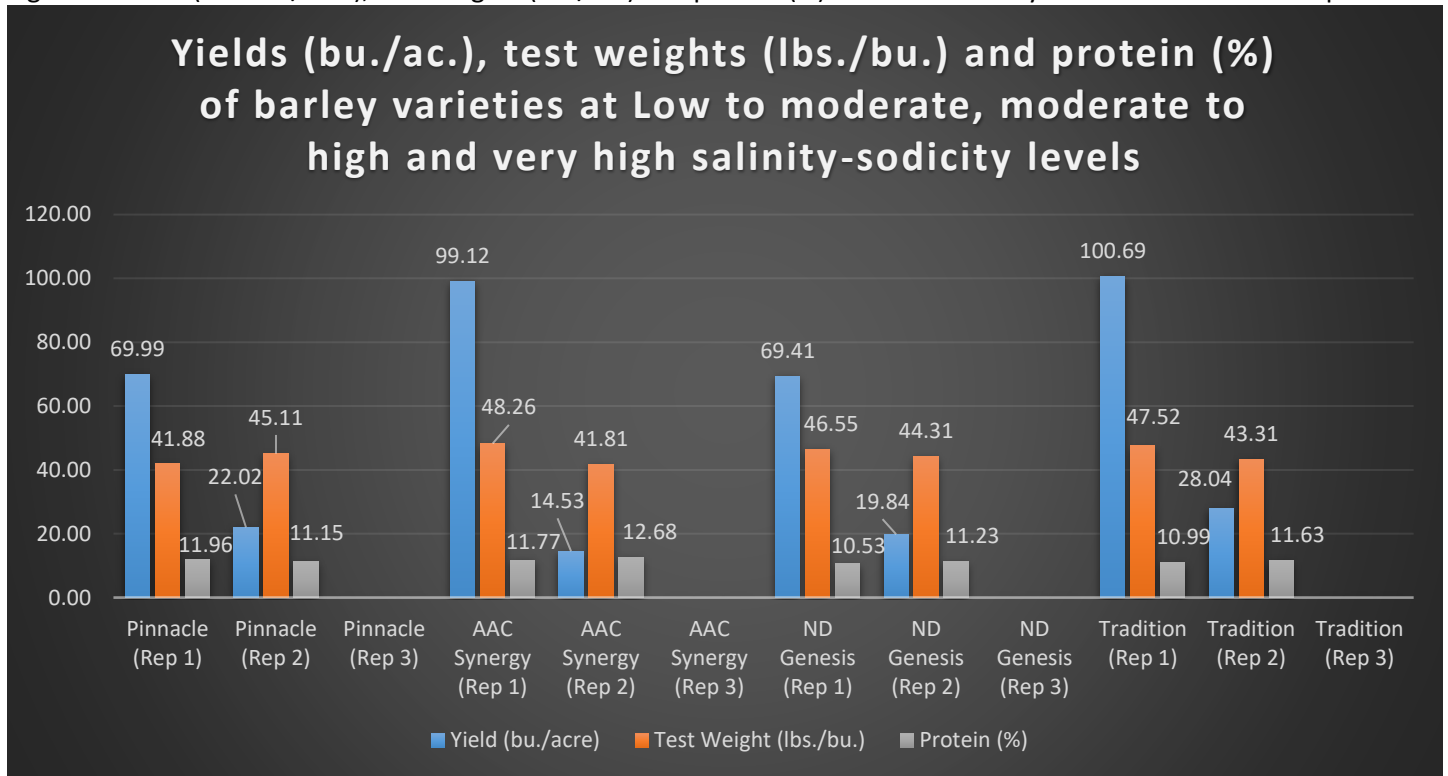
Average barley yield of replication 1 was 84.80 bushels/acre versus 21.10 bushels/acre of replication 2. That was a 75 percent reduction in yield (Figure 1). In replication 1, tradition yielded the highest (100.69 bushels/acre) followed by ACC Synergy (99.12 bushels/acre), Pinnacle (69.99 bushels/acre) and ND Genesis (69.41 bushels/acre). However, at moderate to high salinity-sodicity levels in replication 2 yield trends were different. Tradition still came out as the highest yielding variety with 28.04 bushels/acre followed by Pinnacle (22.02 bushels/acre), ND Genesis (19.84 bushels/acre) and ACC Synergy yielding 14.53 bushels/acre.

ACC Synergy had the highest test weight in replication 1 followed by Tradition, ND Genesis and Pinnacle. Like yields, with the increase in salinity and sodicity in replication 2 test weight trends changed as well. Pinnacle had the highest test weight in replication 2 followed by ND Genesis, Tradition and ACC Synergy. Overall, replication 1 had five percent higher average test weight compared to replication 2.

Unlike yield and test weight, average protein of replication 2 was 3.18 percent higher than replication 1. In terms of varietal differences, Pinnacle had the highest protein in replication 1 followed by ACC Synergy, Tradition and ND Genesis. In replication 2, ACC Synergy had the highest protein followed by Tradition, ND Genesis and Pinnacle. Replication 3 resulted in 100 percent loss.

Overall, Tradition (six-row) barley had the highest yields in replication 1 and 2 versus the other three two-row varieties.

Figure 1. Yields (bushels/acre), test weights (lbs./bu.) and protein (%) of the four barley varieties for all three replications.

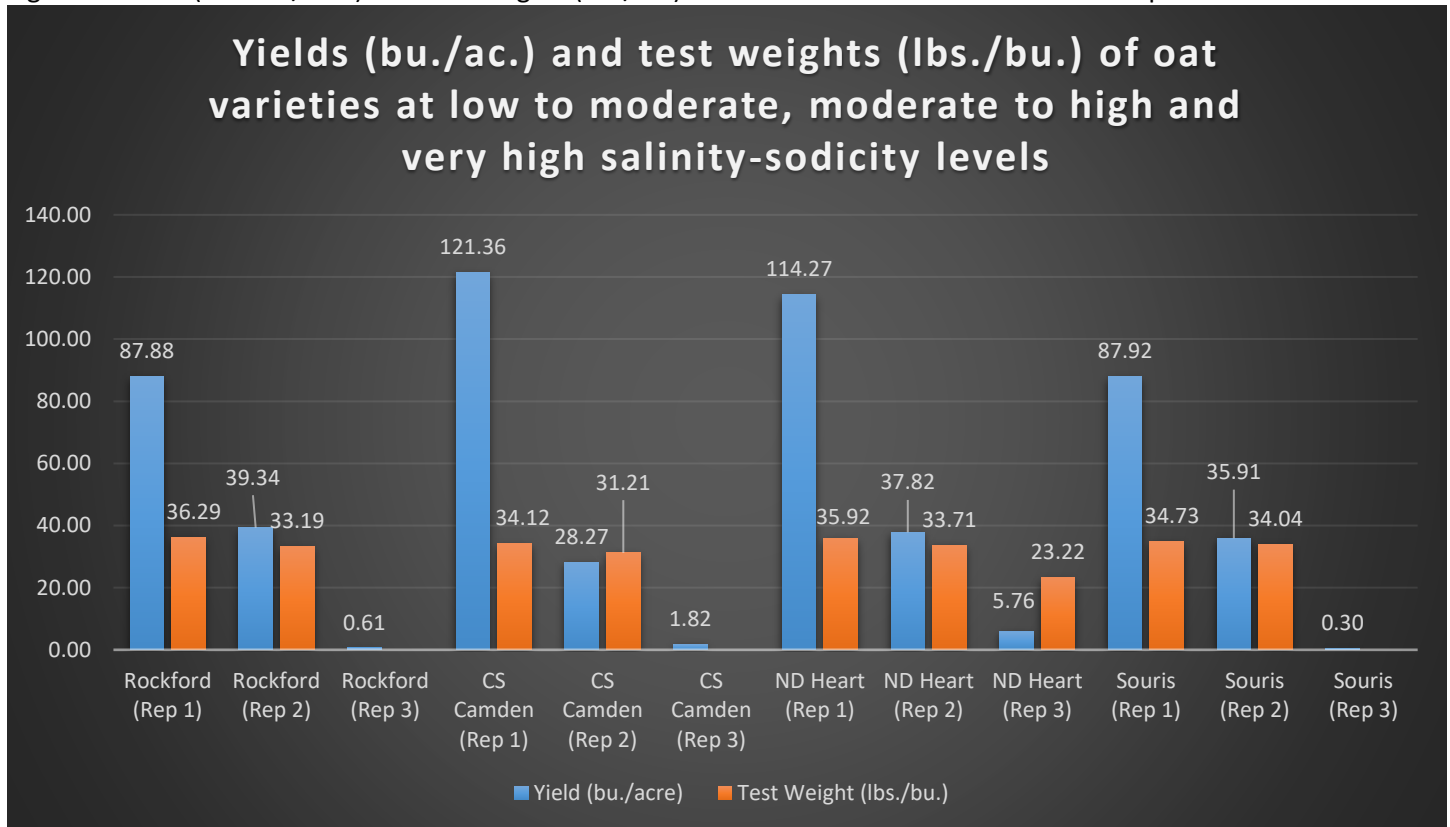


Average yield of oats in replication 1 was 102.85 bushels/acre versus 35.33 bushels/acre of replication 2 and 2.12 bushels/acre of replication 3. That was 65 and 98 percent reduction in yield in replication 2 and 3 compared to replication 1 (Figure 2). CS Camden had the highest yield (121.35 bushels/acre) in replication 1 followed by ND Heart (114.27 bushels/acre), Souris (87.91 bushels/acre) and Rockford (87.88 bushels/acre). Like barley, oat yield trends also changed with the increase in soil salinity and sodicity. In replication 2, Rockford had the highest yield (39.33 bushels/acre) followed by ND Heart (37.81 bushels/acre), Souris (35.90 bushels/acre) and CS Camden (28.26 bushels/acre). All varieties yielded negligibly in replication 3 with ND Heart yielding the most with 5.75 bushels/acre.

Replication 1 had 6.31 and 83.53 percent higher average test weight than replication 2 and 3. Rockford had the highest test weight in replication 1 followed by ND Heart, Souris and CS Camden. Souris had the highest test weight in replication 2 followed by ND Heart, Rockford and CS Camden. ND Heart was the only oat variety that produced a big enough sample in replication 3 to measure the test weight, which was 23.22 (lbs./bushel).

One key observation was that all four oat varieties had some growth in replication 3, whereas, barley had zero growth pointing to a slightly higher salt-sodicity tolerance of oats compared to barley.

Figure 2. Yields (bushels/acre) and test weights (lbs./bu.) of the four oat varieties for all three replications.



## Summary

- Soil surface salinity and sodicity levels (0-6 inch depths) had more impact on the seedbed preparation, germination, plant growth and vigor, maturity, yield and quality than the levels in the 6-24 inch depths. At an EC of 3.99 dS/m and SAR of 7.12 in the 0-6 inch soil depth, both barley and oats produced higher yields and quality. Increased EC and SAR levels in the topsoil may result in significant economic losses.
- Both barley and oat varieties produced variable yields and quality at different salinity and sodicity levels. Varieties that produced higher yields at low to moderate salinity-sodicity levels, yielded lower at moderate to high salinity-sodicity levels.
- Tradition barley (six-row) produced highest yields in replication 1 and 2 versus the other three two-row varieties.
- Oats turned out to be slightly more tolerant to salinity and sodicity compared to barley.